CLAIMS

1. A method for remotely calibrating a phased array system (APA), comprising a number of transmit and/or receive modules (TRM), wherein the transmit gain (δ_j^{Tx}) of each transmit and/or receive module can be set to one of a first collection of complex values (S_n^{Tx}, $d_1^{Tx} \cdot S_n^{Tx}$ ... $d_p^{Tx} \cdot S_n^{Tx}$, $d_i^{Tx} \cdot d_j^{Tx} \cdot S_n^{Tx}$ ...), and/or the receive gain (δ_j^{Rx}) of each transmit and/or receive module can be set to one of a second collection of complex values (S_n^{Rx}, $d_1^{Rx} \cdot S_n^{Rx}$ ... $d_p^{Rx} \cdot S_n^{Rx}$, $d_i^{Rx} \cdot d_j^{Rx} \cdot S_n^{Rx}$ ...), said method comprising the steps of:

i) generating a first (FCS, CS) and a second carrier signal (SCS, CS);

ii) generating a first pulse train by modulating said first carrier signal (FCS, CS) and transmitting it using the phased array system (APA), wherein the transmit gain values of the transmit and/or receive modules (TRM) are set according to a pattern that changes during the transmission of said first pulse train; and/or receiving a second pulse train, generated by modulating said second carrier signal (SCS, CS), using the phased array system (APA), wherein the receive gain values of the transmit and/or receive modules (TRM) are set according to a pattern that changes during the reception of said first pulse train;

iii) demodulating said first pulse train using the second carrier signal (SCS, CS) and/or said second pulse train using the first carrier signal (FCS, CS), in order to determine a first ($R_{STG}(x)$, $R_{Tx}(x)$) and/or second ($R_{GTS}(x)$, $R_{Rx}(x)$) series of complex amplitude values, wherein said first series of complex amplitude values is a first invertible function ($C_{sum}^{Tx}(x)$) of said transmit gains of all the transmit and/or receive modules, affected by at least a first parasitic phase contribution ($e^{i\phi(x)}$, $e^{i\sigma(x)}$), and/or said second series of

complex amplitude values is a second invertible function ($C_{sum}^{Rx}(x)$) of said receive gains of all the transmit and/or receive modules, affected by at least a second parasitic phase contribution ($e^{i\varphi(x)}$, $e^{i\sigma(x)}$);

iv) communicating said first and/or second series of complex amplitude values to a calibration elaboration unit (GS-EU, SAT-EU);

v) removing said first ($e^{i\phi(x)}$, $e^{i\sigma(x)}$) and/or second ($e^{i\varphi(x)}$, $e^{i\sigma(x)}$) parasitic phase contributions from said first ($R_{STG}(x)$, $R_{Tx}(x)$) and/or second ($R_{GTS}(x)$, $R_{Rx}(x)$) series of complex amplitude values to obtain estimates of said first ($C_{sum}^{Tx}(x)$) and/or second ($C_{sum}^{Rx}(x)$) invertible functions;

wherein step v) comprises the operations of :

a. determining first estimates of each individual complex value belonging to said first and/or second collection of complex values from a priori knowledge of the transmit and/or receive complex gain of each transmit and/or receive module (TRM);

b. computing first estimates of said first ($C_{sum}^{Tx}(x)$) and/or second ($C_{sum}^{Rx}(x)$) invertible functions from said first estimates of each individual complex value belonging to said first and/or second collection of complex values;

c. computing estimates of said first ($e^{i\phi(x)}$, $e^{i\sigma(x)}$) and/or second ($e^{i\varphi(x)}$, $e^{i\sigma(x)}$) parasitic phase contributions by removing said estimates of the first ($C_{sum}^{Tx}(x)$) and/or second ($C_{sum}^{Rx}(x)$) invertible functions from said first ($R_{STG}(x)$, $R_{Tx}(x)$) and/or second ($R_{GTS}(x)$, $R_{Rx}(x)$) series of complex amplitude values;

d. modifying said estimates of the first ($e^{i\phi(x)}$, $e^{i\sigma(x)}$) and/or second ($e^{i\varphi(x)}$, $e^{i\sigma(x)}$) parasitic phase contributions by adding a first (ν^{Tx}) and/or second (ν^{Rx}) simulated phase

noises, both having a pre-determined standard deviation ($1/\beta$) and a non-uniform statistical distribution;

e. updating said estimates of said first ($C_{sum}^{Tx}(x)$) and/or second ($C_{sum}^{Rx}(x)$) invertible functions by removing from said first ($R_{STG}(x)$, $R_{Tx}(x)$) and/or second ($R_{GTS}(x)$, $R_{Rx}(x)$) series of complex amplitude values the modified estimate of the parasitic phase contributions determined in operation d.

f. updating the estimates of the individual complex values belonging to said first (S_n^{Tx}, $d_1^{Tx}\cdot S_n^{Tx}$ ... $d_p^{Tx}\cdot S_n^{Tx}$, $d_i^{Tx}\cdot d_j^{Tx}\cdot S_n^{Tx}$ ...) and/or second (S_n^{Rx}, $d_1^{Rx}\cdot S_n^{Rx}$ ... $d_p^{Rx}\cdot S_n^{Rx}$, $d_i^{Rx}\cdot d_j^{Rx}\cdot S_n^{Rx}$ ...) collections by inverting said updated estimates of said first and/or second invertible functions;

and reiterating operations b. to f.

2. A method according to claim 1, wherein step v) further comprises comparing said estimates of said first ($C_{sum}^{Tx}(x)$) and/or second ($C_{sum}^{Rx}(x)$) decoded invertible functions with said "a priori" knowledge of the transmit and receive gain of each transmit and receive module in order to reject aberrant estimates and to replace them with predetermined values.

3. A method according to claim 1 or 2, wherein the statistical distribution of said first (ν^{Tx}) and/or second (ν^{Rx}) simulated phase noise is modified from one iteration of step v) to another in order to ensure a convergence of the estimation procedure.

4. A method according to anyone of the preceding claims, wherein the transmit and/or receive gain values of the transmit and/or receive modules are set according to a pulse-coded calibration encoding pattern for at least a first subset (TCP, RCP) of the pulses belonging to said first and/or

second pulse train and operation f. of step v) of the method comprises performing a pulse-coded calibration decoding of said first subset of pulses.

5. A method according to anyone of the preceding claims, wherein said first ($R_{STG}(x)$, $R_{Tx}(x)$) and/or second (R_{GTS} (x), $R_{Rx}(x)$) series of complex amplitude values are also affected by a third parasitic phase and amplitude contribution (r(x)), which depends on a first set of measurable physical parameters, and wherein said third parasitic phase and amplitude contribution is removed before performing step v) of the method by making use of a measurement (GPSPH) of said first set of physical parameters.

6. A method according to claim 5, wherein said first set of measurable physical parameters includes a time-varying position of said phased array system.

7. A method according to anyone of the preceding claims, wherein both said first ($R_{STG}(x)$, $R_{Tx}(x)$) and second (R_{GTS} (x), $R_{Rx}(x)$) series of complex amplitude values are also affected by a fourth parasitic phase, or phase and amplitude, contribution (A(x)), which depends on a second set of physical parameters which vary on a time scale much longer than the interval separating two pulses of said first and/or second pulse train, and wherein said fourth parasitic phase, or phase and amplitude, contribution is removed before performing step v) of the method.

8. A method according to claim 7 when dependent on claim 4, wherein the transmit and/or receive gain values of the transmit and/or receive modules (TRM) are set according to a pulse-coded calibration encoding pattern for only a first subset (TCP, RCP) of the pulses belonging to said first and/or second pulse train, while they are set according to a fixed pattern for a second subset (TRP, RRP, RP) of the pulses, said second subset being used to remove said fourth parasitic phase, or phase and amplitude, contribution (A(x)), but not to perform step v) of the method.

9. A method according to claim 8, wherein removal of said fourth parasitic phase, or phase and amplitude, contribution (A(x)) comprises repeatedly fitting said fourth parasitic phase, or phase and amplitude, contribution with suitable fitting functions until a suitable stop criterion is met.

10. A method according to claim 9, wherein said stop criterion is the fact that the cross-correlation between said first ($R_{STG}(x)$, $R_{Tx}(x)$) and second (R_{GTS} (x), $R_{Rx}(x)$) series of complex amplitude values reaches a minimum.

11. A method according to claim 9 or 10, wherein said fitting functions are polynomials of increasing orders.

12. A method according to claim 7 to 11, wherein said second set of physical parameters comprises the characteristics of the medium through which the first and/or second pulse train propagate.

13. A method according to anyone of the preceding claims, wherein said first ($e^{i\phi(x)}$) and/or second ($e^{i\varphi(x)}$) parasitic phase contributions are originated by hardware-induced phase noises affecting said first (FCS) and second (SCS) carrier signals.

14. A method according to anyone of the preceding claims, wherein said first carrier signal (FCS) is generated by a first local oscillator (SAT-LO) co-located with the phased array system (APA) and said second carrier signal (SCS) is generated by a second local oscillator (GS-LO) located at a remote station (GS) which receives said first pulse train and/or transmits said second pulse train, and wherein said first (FCS) and second (SCS) carrier signal, if both are present, may be mutually incoherent.

15. A method according to anyone of claims 1 to 12, wherein said first and second carrier signals (CS) are both generated by a local oscillator (SAT-LO) co-located with the phased array system (APA) and are both transmitted from said phased array system, reflected by a remote reflecting target (RT) and received by the same phased array system, and wherein said first and second parasitic phase contributions ($e^{i\sigma(x)}$) are originated by variations in the radar cross section of said remote reflecting target (RT).

16. A method according to claim 15, wherein the receive gain values of the transmit and receive modules (TRM) are set according to a fixed pattern during reception of the first pulse train and wherein the transmit gain values of the transmit and receive modules are set according to a fixed pattern during transmission of the second pulse train.

17. A method according to claims 15 or 16, wherein the first and second pulse train are interleaved.

18. A method according to anyone of the preceding claims, wherein said phased array system (APA) is a phased array antenna.

19. A method according to claim 18, wherein said antenna is carried by a satellite (SAT).

20. A method according to claim 19, where depending from claim 12, wherein said remote station is a ground station (GS).

21. A method according to claim 19, where depending from claim 13, wherein said remote reflecting target (RT) is a ground target.